Technology Opportunity

Pump Design and Analysis Codes

NASA Lewis has computational modeling capabilities for designing pumps. The analysis and design tools range from "quick look" to fully viscous three-dimensional (3-D) codes. A one-dimensional (1-D) empirical-based flow code (PUMPA) is used during pump conceptual design. A blade geometry generation code (CCGEOM) is used to design 3-D blades for axial or centrifugal pumps and other turbomachinery. A quasi-three-dimensional (Q3D) empirical-based analysis code (MTSB) is used to analyze the flow field within the pump blades and stators. A 3-D Navier-Stokes viscous flow code (RVC3D) is used to further analyze the details of the flow field within pump rotors during the design process. As a result of this iterative design process, a highly refined pump geometry can be achieved. These codes, which are described in more detail herein, are available from NASA Lewis Research Center's Commercial Technology Office.

Potential Commercial Uses

The codes can be used to design continuous flow pumps for the following applications:

- Artificial heart blood pump
- Jet-ski pump for propulsion
- Chemical process pump
- Spray-paint pump

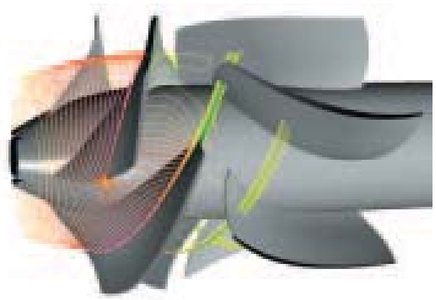
Benefits

- Higher efficiencies
- Faster design cycle times

The Technology

Three-Dimensional Pump Flow Analysis Code (RVC3D)

RVC3D is a Navier-Stokes viscous flow code that can be used to further analyze the details of the flow field within pumps. Since it is a Navier-Stokes code,



RVC3D calculates the hydraulic and internal leakage losses within the pump blade row during the final phases of the pump design process. The output consists of all velocities, pressures, and temperatures inside the blade row.

RVC3D is somewhat complex, so in order to derive the greatest benefit from its advanced features, it requires an engineer with knowledge of the fluid dynamics occurring inside a turbomachine. The input is more complex than for MTSB, and interpretation of the results is more complicated. An advanced visualization tool such as FAST, PLOT3D, VISUAL3, Tecplot, or Fieldview is required for proper visualization of the calculated flow field. Setup time for RVC3D is generally less than 2 weeks. CPU runtime is on the order of hours to days, depending on the computational resources available.

Turbomachinery Geometry Generation Code (CCGEOM)

CCGEOM can generate the full 3-D pump blade geometry. It can be used for all pump configurations, including axial or inducer, mixed-flow and centrifugal impeller rotors and diffuser vanes. CCGEOM is used iteratively with the Q3D and 3-D pump flow codes described herein. It is written so that the designer can input sparse geometric information at the beginning of the design phase and progress to more detailed specifications later in the design phase as results from the Q3D and 3-D analysis codes are obtained.

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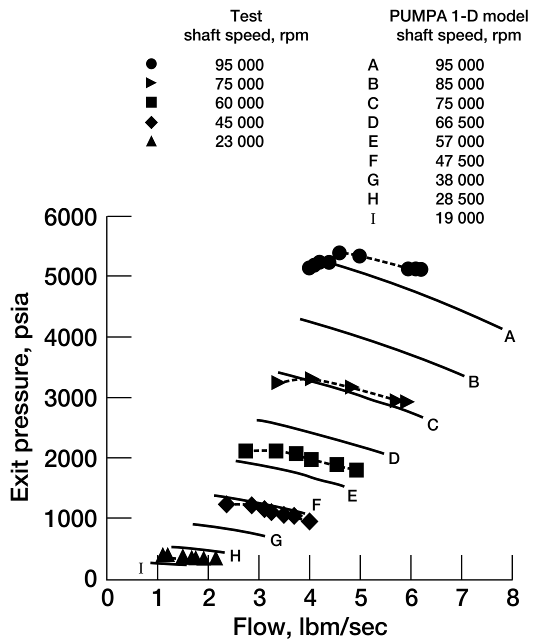

Pump map: pressure vs. flow

CCGEOM should be run by a technologist familiar with turbomachinery blade definition. Once overall dimensions are available from either PUMPA or from an existing design, the details of the three-dimensional blading can be input in less than an hour and the code run in a matter of seconds on a workstation or PC. Changes to CCGEOM input as a result of the analyses from the Q3D or 3-D codes require an engineer with some knowledge of turbomachinery design.

Quasi-3-Dimensional Pump Flow Analysis Code (MTSB)

The MTSB code analyzes the details of the flow field within pump rotors and stators. It calculates the hub-to-tip and the blade-to-blade flow conditions within pump blade passages. The inviscid flow code estimates pump blade efficiency by means of a boundary layer analysis and correlations of tip clearance losses, secondary flow losses, and the like. MTSB can be used in the design process iteratively with CCGEOM. The output consists of the calculated velocities and pressures inside the blade row passages and estimates of overall blade row performance.

MTSB should be used by an engineer with some knowledge of the internal flows in turbomachinery. Since CCGEOM writes an input file for MTSB, which requires only slight modification by the user, setup time is minimal. An engineer should be able to modify the input file in a matter of minutes and run the analysis in a few minutes on a workstation. Preparing the input geometry is somewhat more involved if the engineer must define it from engineering drawings; however, this should take no more than 1 or 2 days. To interpret the results, the engineer must have some knowledge of the fluid flow in turbomachinery.

One-Dimensional Pump Flow Analysis Code (PUMPA)

The 1-D analysis code PUMPA can be used to size axial and centrifugal pump configurations and to estimate off-design performance. The output from PUMPA includes estimates of velocities, flow angles, pressure at the blade leading and trailing edges, and overall power. PUMPA can model single and multistage pumps and can handle the following fluids: water, liquid hydrogen, liquid oxygen, liquid nitrogen, liquid helium, air and kerosene. Other fluid properties can be added. The code considers cavitation and estimates the dimensions of the diffusion system and the volute throat.

PUMPA can be run by an engineer; however, interpretation of the output requires an engineer with knowledge of overall pump performance. If overall pump geometry is known, PUMPA can be set up in less than 1 hr and run on a PC in a matter of seconds.

Options for Commercialization

NASA Lewis has no patents on the codes and has released most of them to COSMIC. Any company may acquire the codes and improve them. The codes may be used to develop enhanced design tools for commercial applications.

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Key Words

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Analysis	Turbopump
Design	Inducer
Flow	Centrifugal
Fluid dynamics	Axial
Cavitation	

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